HYDROGEOLOGY ASSESSMENT USING PHYSICAL PARAMETER IN BENGKALIS RIAU

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Abstract

Saltwater intrusion became an important issue at coastal region because it can affect the fresh water quality in surrounding areas. Jangkang and Deluk village which located in the northern coast of Bengkalis Island, facing similar problem therefore an initial stage of groundwater mapping and water quality assessment has been conducted by measuring 56 dug wells to obtain some information such as shallow groundwater aquifer depth, colour and taste of groundwater, and physical parameters including temperature, pH, electrical conductivity (EC) and total dissolved solid (TDS). Depth of well had been measured using a simple scheme whereas the physical parameters was measured using YSI Pro 1030 Water Quality Instrument. These parameters being used to determine the water quality by comparing to water quality standards, Permenkes 2010 No. 492 and WHO Drinking Water Quality Standard 2011. Several groundwater maps had produced such as groundwater contour map, groundwater taste map, pH isopach map, TDS isopach map and EC isopach map. The contour map shows the presence of conus in the northeast and central part of research area that indicating the excessive use of groundwater and higher possibility to the occurrence of saltwater intrusion. Groundwater taste map, TDS isopach map and EC isopach map shows similar pattern, the salinity of groundwater tends to be increased to the northern area. According to the water quality standard, 55% of water sample in the study area is in good condition to be drink, 12.5% is permissible to drink and 32.5% is not recommended to drink. The residence in the research area particularly work as a fisherman, based on the water quality assessment, 94% of water sample is suitable for irrigation purpose hence agricultural activity could be another option for the residence to utilize their land and improved their economic condition.
Keywords: Saltwater intrusion, Bengkalis, groundwater quality

1. INTRODUCTION

Jangkang and Deluk village tend to have water quality problem by salt water intrusion due to those villages located on the northern coast of Bengkalis Island, Riau Province. The study was initiated from the result of water quality analysis in the northern area of Bantan Tua village which adjacent directly to Jangkang and Deluk village. This area was found to have brackish water in its river owing to a certain amount of salt water mixing [1]. The objective of this study is to identify the water quality from several unconfined aquifers around the villages and to determine the suitable purpose of groundwater usage.

Jangkang and Deluk village located on the northern coast of Bengkalis Island, Bengkalis Regency, Riau Province. The study area lies between 170248 N – 173443 N latitudes and 185374 E – 188327 E longitudes (Fig. 1). The study area has the strait of Malacca as its direct border in the north and Bantan Tua village in the south.

Fig. 1. Study area located on the northern coast of Bengkalis Island

2. LITERATURE REVIEW

Uneven distribution of clean water throughout the world resulting from rapid population growth and various daily activities became a major factor to decreasing in clean water availability [2]. Excessive use of groundwater resource would also reduce environmental quality [3], [4], [5], [6], [7], [8] and [9]. Groundwater would continuously be exploited to meet the needs of clean water because it has a better quality rather than surface water [10].

The coastal area facing a more complex situation as population of the world highly accommodating this area, thus there is a possibility of mixed or intruded by saltwater as a result of groundwater over-pumping [11], saltwater would be able to push into groundwater and reduce the water quality in that area [12]. An important factor in assessing and classify water quality is physical and chemical parameters [13], [14] to get to know the intrusion level of groundwater.

3. METHODOLOGY

Research activities conducted in September 2016 while a dry season and low rainfall intensity in Bengkalis Island, but at the time this research had conducted, rain occurred for two days thus might affect the water quality. Water sample had been obtaining from 56 dug wells that found in the study area (Fig. 2). Shallow groundwater depth measured using manual and simple tools such as rope, stone and tape rule. Elevation and coordinate of each dug well position had been acquired using GPS.

The physical parameters of water samples measured in the field are color, taste, temperature, pH, electrical conductivity (EC) and total dissolved solid (TDS) [1]. Those parameters divined using YSI Pro-1030 Water Quality Instrument. The data then being assesses by comparing to [15] and [16]. The results would show the percentage of groundwater that suitable for drinking water and other purposes.

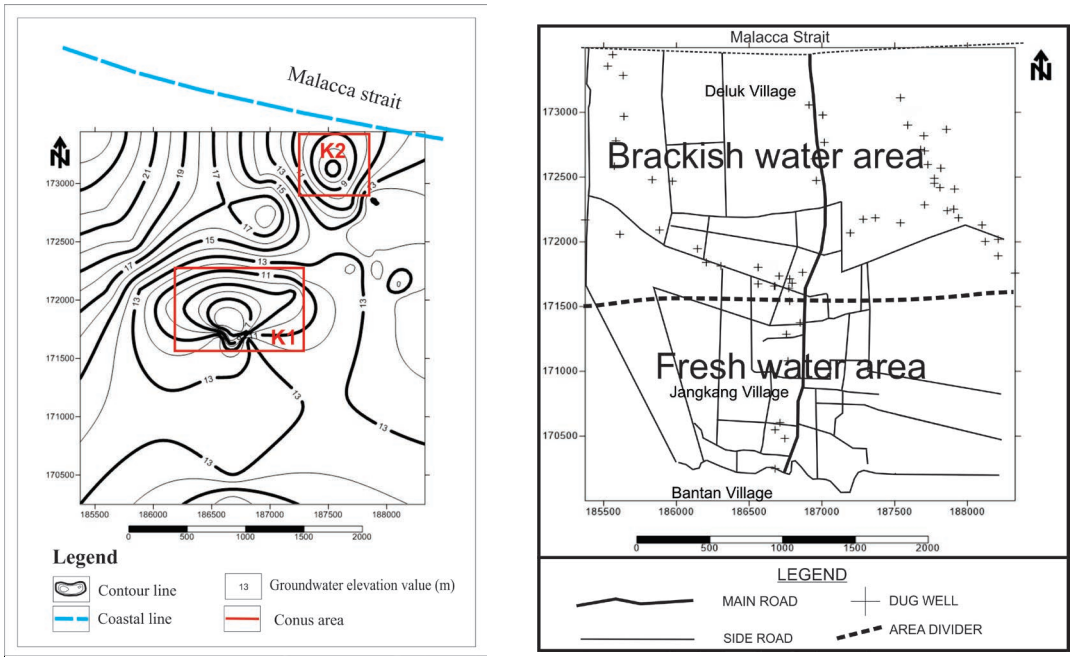
Fig.2. Location map of 56 dug wells water analysis (shown by white dots)

4. RESULTS AND DISCUSSION

The data of each dug well being processed to produce shallow groundwater isopach map (Fig. 3a) and groundwater taste map (Fig. 3b). Physical parameters such as temperature, pH, EC, and TDS had been used as a comparison to water quality standard.

4.1 SHALLOW GROUNDWATER CONTOUR MAP

Groundwater isopach map (Fig. 3a) had been produced in accordance with measurement method. Groundwater elevation is in the range of 5.2 - 24.7 m.a.s.l. Shallow groundwater isopach map shows the occurrence of two conus features in the central part (K1) and northeast part (K2). These areas are densely populated, therefore, the conus indicating the high usage of groundwater. Conus K2 is in the area that closed to the shoreline, as a result this area was more vulnerable to sea water intrusion. Groundwater taste map (Fig 3b) seemingly proofed this statement as it shows the increasing of water salinity from the central part to the north part.



(a) (b)

Fig. 3. Shallow **g**roundwater isopach map (a) and Groundwater taste map (b)

4.2 PHYSICAL PARAMETERS WATER QUALITY ASSESSMENT

The assessment of each parameter would be evaluated to obtain the water quality information.

a. Temperature

Temperature condition of groundwater in the study area is in a normal condition in ranging between 27.0^{o}C – 30.5^{o}C. Based on the [16], the regulation of drinking water temperature is ± 3^{o}, so that the groundwater in study area considered as normal.

b. pH

Based on [15] and [16] the normal pH for drinking water is 6.5-8.5. In general, pH of groundwater in the study area is in those categories, but there are two wells that exceed the value, well number jkg_61 (8.56) and jkg_68 (8.52). Most of the wells show the high pH value as suitable to the sea water characteristic with sort of value 7.5-8.4 (Fig. 4a).

c. Electrical conductivity (EC)

EC value of the groundwater in the study area is in between 105.10 - 5650 µS/m (Fig. 4b). Based on classification by [17], EC value that more than 2000 µS/m indicating the contamination of saline water, hence, 27% of groundwater exceeding this value, 16% is on the transition and the

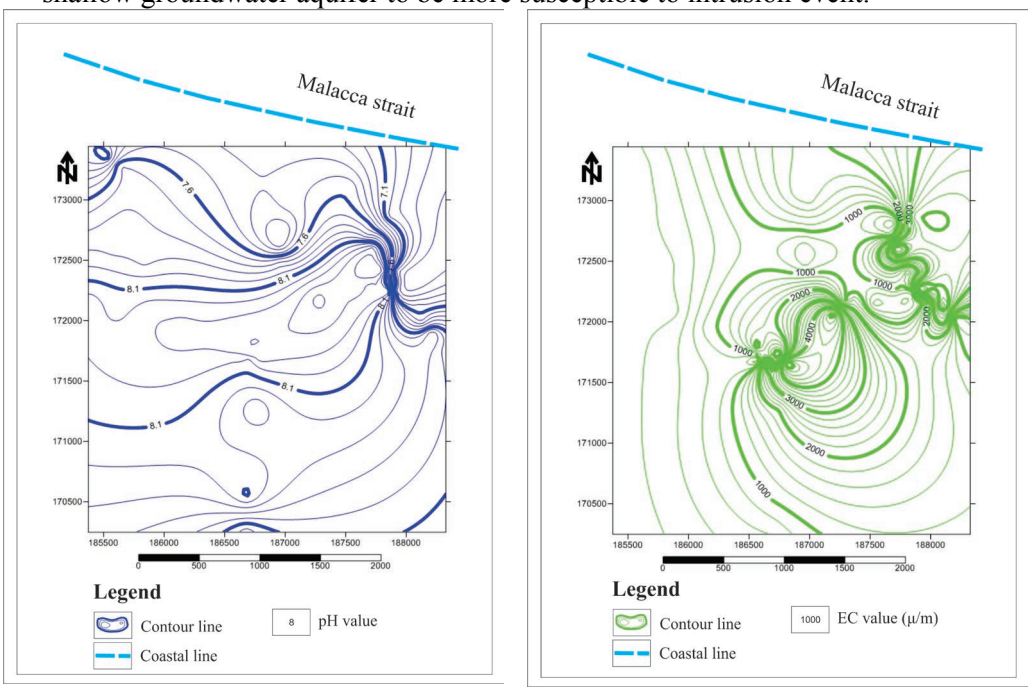
remain sample is fresh water. Water that being contaminated by salt water commonly found in the northern part.

d. Total dissolved solid (TDS)

TDS value had been used to classify the groundwater in the study area based on [18]. There are two classes of water, fresh water, and brackish water. The brackish water (higher TDS) generally had been found from the central part to the northern part of the study area (K1 and K2 location). This result also supports the groundwater taste map that shows a similar result. Lower TDS value also found in several wells at the northern part, this might be as a result of rainfall that happened during the data collection. Based on [15] and [16], TDS value that considerable as drinking water is below 600mg/L. TDS value of groundwater in the study area ranging in 79.90 – 3420mg/L (Fig. 6a), 55% of groundwater is in good condition, 12.5% is in proper condition and 32.5% is not recommended for drinking water. The residence in the research area particularly work as a fisherman, based on the water quality assessment, 94% of water sample is suitable for fish pond watery and irrigation purpose hence agricultural activity could be another option for the residence to utilize their land and improved their economic condition.

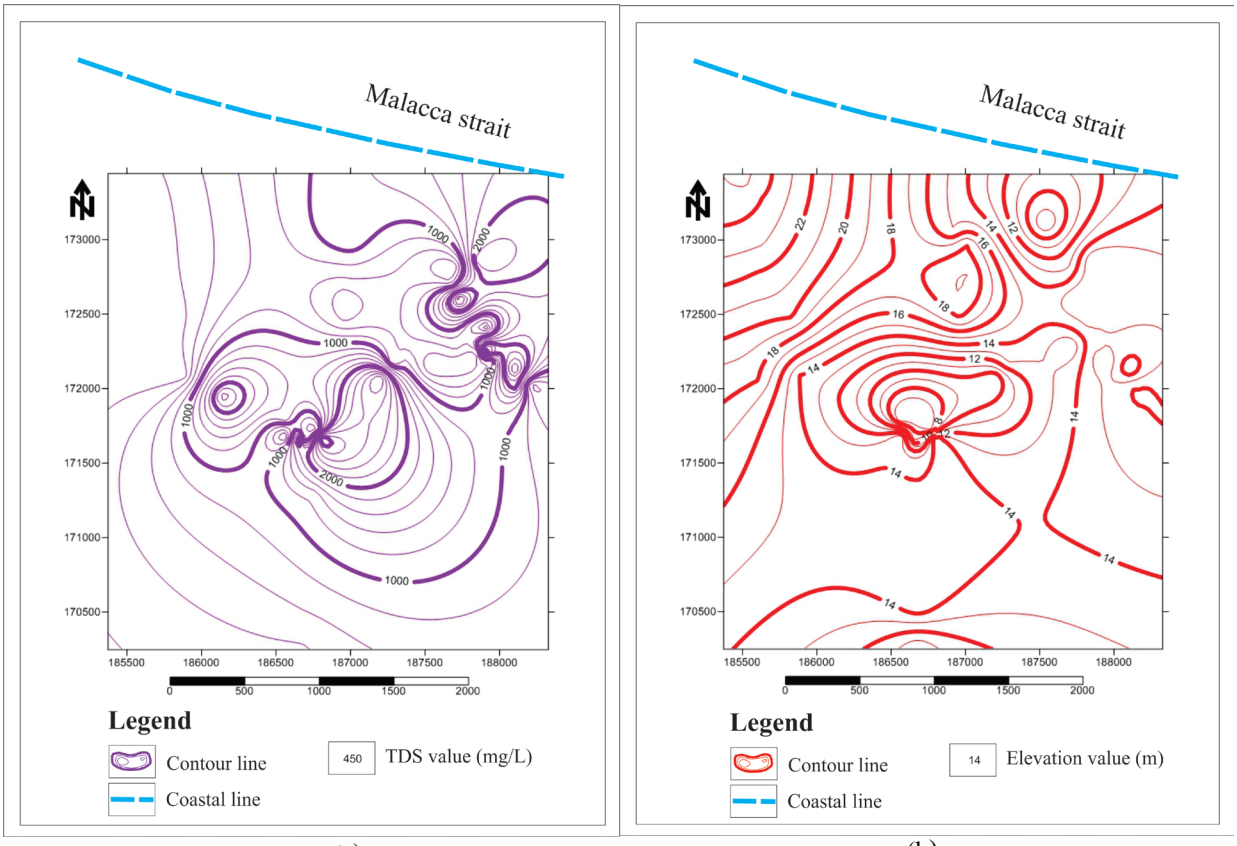
e. Comparison of pH, EC, TDS and elevation map

The surface elevation of study area is in between 7-25 m.a.s.l which consider as relatively flat area (Fig. 6b). Comparison of pH, EC, TDS and elevation map shows the conus area that indicating as saltwater intrusion region is the result of groundwater over-used, efecting the shallow groundwater aquifer to be more susceptible to intrusion event.



(a) (b)

Fig. 4. pH isopach map (a) and EC isopach map (b) of the groundwater in the study area



(a) (b)

Fig. 5. Comparison between TDS isopach map (a) and elevation map (b)

5. CONCLUSIONS

From the shallow groundwater isopach map and physical parameters assessment, water quality of the study area is in good condition but in a certain part, especially in the northern part, the groundwater had been mixing with the saline water as a result of sea water intrusion by excessive use of water resource. However, the intrusion is still in the lower level and groundwater quality could have been recovered with a few treatments.

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REFERENCES

1. D.B.E. Putra, Y. Yuskar, Pemetaan Airtanah Dangkal dan Analisis Intrusi Air Laut, Penelitian Terhadap Airtanah Dangkal di Desa Bantan Tua, Kecamatan Bantan, Kabupaten Bengkalis, Propinsi Riau, *Proc. Nat. Sem. of Fac. of Geol. Eng. Univ. Padjadjaran*, **3**, p1.11 (2016)
2. H. Annapoorna, M.R. Janardhana, Assessment of Groundwater Quality for Drinking Purpose in Rular Areas Surrounding a Defunct Copper Mine, *Aquatic Procedia*, **4**, 685-692 (2015)
3. R.K. Srivastva, W.S. Fargo, V.S. Sai, K.C. Mathur, Water Quality Along the Sone River Polluted by the Orient Paper Mill, *Water Air Pollut.*, **39**, 75-80 (1988)
4. B. Baykal, A. Tanik, I.E. Gonenc, Water Quality in Drinking Water Reservoirs of a Megacity, Istanbul, *Env. Mngmnt*. **26**, 607-614 (2000)

5. N. Mladenov, K. Strzepek, O.M. Serumola, Water Quality Assessment and Modeling of an Effluent–Dominated Stream. The Notwane River. Botswana. *Env. Monit. Assmnt.*, **109**, 97-121 (2005)
6. M.O. Jaji, O. Bamgbose, O.O. Odukoya, T.A. Arowolo, Water Quality Assessment of Ogun River, South West Nigeria, *Env. Monit. Assmnt.*, **133**, 473-482 (2007)
7. D. V. Mockovchenko, A.G. Babushkin, G.N. Artamonova, Surface Water Quality Assessment of the Vatinsky Egan River Catchment, West Siberia, *Env. Monit. Assmnt.*, **148**, 359-368 (2009)
8. F. Gultekin, F.E. Arzu, H. Esra, C. Secil, Quality Assessment of Surface and Groundwater in Solakli Basin, Trabson, Turkey, *Bul. Eng. Geol. Env.*, **72**, 213-224 (2013)
9. G. Tayfur, T. Kirer, A. Baba, Groundwater Quality and Hydrochemical Properties of Torbah Region, Izmir, Turkey, *Env. Monit. Assmnt.*, **146**, 157-169 (2008)
10. M.S.D. Hadian, F. N. Azy, I. Krismadiyanti, D.L. Arfani, E.T. Sofyan, T. Prayogi, Groundwater Quality Assessment for Suitable Drinking and Irrigation Using Physico-Chemical Water Analysis in the Rancaekek-Jatinangor District, West Java, Indonesia, *Int. Proc. of Chem., Bio. and Env. Eng.*, **84**, 56-62 (2015)
11. F. Wagner, T.D. Trung, H.D. Phuc, F. Lindenmaier, Assessment of Groundwater Resources in Nam Dinh Province, Improvement of Groundwater Protection in Vietnam (2011).
12. Prince Edward Island Department of Environment, Labour and Justice, Saltwater Intrusion and Climate Change (2011)

    http://www.gov.pe.ca/photos/original/cle_WA1.pdf Download on 27 October 2016
13. W.P. Kelley, Permissible Composition and Concentration of Irrigation Water, *Proc. ASCE* (1940), **66**, 607.
14. L.V. Wilcox, The Quality Water for Irrigation Use, *US. Dept. Agric. Bull* (1948), **1962**, 40.
15. WHO. Guidelines for drinking water quality. Geneva: World Health Organization. (2010)
16. Indonesian Ministry of Health, Regulation No. 492/MENKES/PER/IV/2010, Drinking water quality regulation (2010)
17. S. Mandel, Z.L. Shiftan, Groundwater Resources: Investigation and Development, *Aca. Press*, **1** (1981)
18. R.A. Freeze, J.A. Cherry, Groundwater, *Prent. Hall, USA*, **1** (1979)